Recent Advances in Standardization on 3D Quality of Experience

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1. Introduction

For the last decades, video quality assessment has mostly tackled 2D video sequences. Technological advances were mostly tackling coding and transmission schemes while the display technology, especially in lab viewing environments, could be considered as transparent. Subjective assessment methodologies needed to be selected mostly with respect to the severity of the degradations. Typical examples are Absolute Category Rating with Hidden Reference (ACR-HR) from ITU-T P.910 for strong degradations experienced in networked multimedia scenarios, and Paired Comparison (PC) or Double Stimulus Continuous Quality Scale (DSCQS) from ITU-R BT.500 for near lossless scenarios such as satellite transmissions.

The introduction of affordable stereoscopic 3D viewing not only in digital cinemas but also in the home environment recently led to new technological developments. For example, in terms of standardization for coding and transmission requirements, the Digital Video Broadcasting Project (DVB) and the European Broadcasting Union (EBU) provide interim recommendations regarding producing, exchanging, archiving, distributing, coding, and transmitting 3D programs using 2D compatible or newly developed 3D infrastructure and transmission technologies.

In analyzing this production and broadcasting chain, one challenge is the measurement of the perceived video quality. for this emerging content. Three main issues were identified.

Firstly, the display device was no longer transparent enough for the observers. While restrictions of 2D devices were widely accepted, i.e. a flat screen with a colored bezel of a certain extent, standing on some surface at a certain viewing distance, 3D viewing introduced glasses based technologies with reduced brightness and reduced temporal or spatial resolution, for active shutter glasses or passive polarized technology respectively. Different 3D display technologies influence the viewing experience differently and none of them can be considered as mature as 2D displays.

Secondly, due to the "added value of depth", the traditional one dimensional concept of "quality" for 2D video sequences is not sufficient to measure all sensations involved in a communication service for stereoscopic 3D. Quality of Experience (QoE) was proposed as a global term and it has been defined in different ways in literatures nowadays. A well approved definition has been provided in the Qualinet White paper summarizing various recent publications from more than 20 research groups [1]. QoE is defined as "the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his or her expectations with respect to the utility and / or enjoyment of the application or service in the light of the user's personality and current state". QoE in 3D is often split into three basic perceptual dimensions: Picture Quality, Depth Quality, and Visual Comfort. Higher level concepts, e.g. naturalness and presence, are then derived from these dimensions which ultimately lead to a global QoE value.

Thirdly, the subjective assessment methodology itself needs to be reconsidered. Observers feel comfortable with providing an absolute 2D video quality score because they know well what to expect from 2D videos. As 3D technology is not used on a daily basis, such an internal reference scale may not be available to observers in 3D stereoscopic experiments. Reliability and reproducibility become questionable which in turn calls for improvements in currently standardized testing methodologies. Therefore, either multi-dimensional scale value need to be used or direct comparison with the reference or between degraded sequences is required. Whether these methodologies provide similar results and may therefore be considered reliable and reproducible is still an open question.
Current standardization activities related to these three issues are presented in the following sections.

2. Display Characterization: SID's ICDM standard

ITU-R BT.500 has been the reference standard for display specifications for the past decades. Its specifications mostly concerned brightness and contrast measurements which could be performed with calibrated luminance meters. Current stereoscopic 3D displays require further characterization on the newly added perception issues, concerning for example:

- The measurement of crosstalk, i.e. the amount of light that is perceived by one eye while it is destined for the other eye.
- Viewing angle measurements, which are

particularly important with autostereoscopic and polarized screens. The physical distance between the screen's pixel illumination and the view dividing material, for example, a parallax barrier, a lenticular array sheet, or a line polarizing foil, introduces a view position dependency which may even lead to the inversion of the stereoscopic views at extreme positions.
- The contrast ratio and the luminance uniformity, which are often influenced nowadays by display specific post-processing methodologies. For example, overdrive technology allows achieving a very fast response time in terms of black-to-white or grey-to-grey. For stereoscopic displays this may introduce view asymmetries.

The Society of Information Display (SID) recently published a standard created by its International Committee for Display Metrology (ICDM). The Information Display Measurement Standard (IDMS) contains methods for reproducible measurement of display variables for various display types as well as requirements for the measurement devices, such as angular resolution for luminance meters, a parameter particularly important for measuring autostereoscopic displays [2].
The standard focuses on measuring technological variables which impact Quality of Experience measurements in subjective assessments without quantifying their influence on perception

3. Multi-scale measurement of 3DTV broadcasting: ITU-R BT.2021 Recommendation
Subjective methodologies for the assessment of stereoscopic 3DTV systems including general test methods, grading scales and viewing conditions have been recently combined in ITU-R BT.2021[3]. Four subjective methods from ITU-R BT.500 are included in this recommendation, which are Single-Stimulus (SS), DSCQS, PC and Single Stimulus Continuous Quality Evaluation (SSCQE). These methods are suggested to measure the three primary dimensions of QoE independently: Picture Quality, Depth Quality and Visual Comfort. They are not suggested to be used for the assessment of naturalness, sense of presence, or overall QoE. As depth quality and visual comfort are new added terms for the traditional 2D methods, these methods should be used with a slight modification. For example, for assessing the visual comfort, the continuous scale is labeled with the attributes "Very comfortable", "Comfortable", "Mildly uncomfortable", "Uncomfortable", and "Extremely uncomfortable".

The viewing conditions are consistent with the 2D viewing conditions recommended by ITU-R BT.2022[4]. The selection of the test video sequences should be performed carefully as visual discomfort or visual fatigue might generate safety and health issues for the viewers. Experiments that aim particularly at measuring visual comfort are exempted from this rule. The maximum value of the disparity, the discrepancies between left and right images including geometric distortions, brightness discrepancy and crosstalk, and the change on distribution of the disparity, etc. are factors that need investigation during the video selection.

Furthermore, the vision screening process, instructions prior to the experiment, the training session, and the duration of the formal test are different from 2D studies in order to deal with visual discomfort issues.

4. Efforts towards international standardization in 3DTV
While some results of the world-wide research has been recently integrated into standards as shown above, further research is ongoing to refine the measurements and to prove their reliability and reproducibility. The 3DTV group of the Video Quality Experts Group is working on the three distinct projects. The first project aims at establishing a Ground Truth database for 3D QoE measurement methodologies by evaluating a reasonably large dataset with Paired Comparison methodology as it has been widely accepted that people may express their preference for one of a pair of sequences. The second project studies the influence factors of the viewing environment on reproducible QoE measurements with emphasis on video quality. The third project is the validation of objective models to predict the perceived quality of stereoscopic video sequences when the degradations are mostly related to video quality and not to visual comfort or depth issues. These efforts are stimulating discussions in the ITU-T Study Group 9 and the ITU-R Study Group 6.

Furthermore, studies are being progressed on scalable view-range representation for free viewpoint television (FTV). The Society of Motion Picture & Television Engineers (SMPTE) focuses on the standardization related to stereoscopic 3DTV in production environments, e.g., the exchange of 3D content amongst mastering facilities, and between a mastering facility and the ingest facility of a distribution system. This includes the specification of requirements for a data representation of disparity maps, methods to transport a pair of stereoscopic frames within single video frames, etc.[5].

IEEE P3333, which is a so-called individual-based project approved by the IEEE Standards Association, works on the quality assessment of 3D Displays, 3D Contents and 3D Devices based on Human Factors, such as photosensitive seizures, motion sickness and visual fatigue and identify and quantify the causes of those factors.

5. Conclusion

The reliable and reproducible assessment of 3D stereoscopic contents is progressing and intermediate standards have been established allowing the industry to perform the required quality assurance tasks. It should be noted that many guidelines provide rather conservative specifications that may reduce the public interest in 3D transmissions. Most of the cited standards and organizations are open to revisions when new evidence becomes available from scientific studies and cross-validations.

References

[1] P. Le Callet, S. Möller, A. Perkis, eds, "Qualinet White Paper on Definitions of Quality of Experience (2012)", European Network on Quality of Experience in Multimedia Systems and Services (COST Action IC 1003), Lausanne, Switzerland, Version 1.1, June 3, 2012

[2] Society for Information Display - International Committee for Display Metrology, "Information Display Measurements Standard (IDMS)", 2012

[3] International Telecommunication Union - Radiocommunication Sector, "Recommendation ITU-R BT.2021: Subjective methods for the assessment of stereoscopic 3DTV systems", 2012

[4] International Telecommunication Union - Radiocommunication Sector, "Recommendation ITU-R BT.2022: General viewing conditions for subjective assessment of quality of SDTV and HDTV television pictures on flat panel displays", 2012

[5] International Telecommunication Union - Radiocommunication Sector, "Report ITU-R BT.2160-2: Features of three-dimensional television video systems for broadcasting", 2012

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Marcus Barkowsky received the Dr.-Ing. degree from the University of Erlangen-Nuremberg in 2009. He joined the Image and Video Communications Group at IRCCyN at the University of Nantes in 2008, and was promoted to associate professor in 2010. His activities range from modeling effects of the human visual system, in particular the influence of coding, transmission, and display artifacts in 2D and 3D to measuring and quantifying visual discomfort and visual fatigue on 3D displays using psychometric and medical measurements. He currently co-chairs the VQEG "3DTV" and "Joint Effort Group Hybrid" activities.

Patrick Le Callet received M.Sc. degree PhD degree in image processing from Ecole Polytechnique de l'Université de Nantes. He was also student at the Ecole Normale Superieure de Cachan where he got the "Aggrégation" (credentialing exam) in electronics of the French National Education. Since 2003, he is teaching at Ecole Polytechnique de l'Université de Nantes in the Electrical Engineering and the Computer Science department where he is now Full Professor. Since 2006, he is the head of the Image and Video Communication lab at CNRS IRCCyN, a group of more than 35 researchers. He is mostly engaged in research dealing with the application of human vision modeling in image and video processing. His current centers of interest are 3D image and video quality assessment, watermarking techniques and visual attention modeling and applications. He is co-author of more than 190 publications and communications and co-inventor of 13 international patents. He has coordinated and is currently managing for IRCCyN several National or European collaborative research programs. He is serving in VQEG (Video Quality Expert Group) where he is co-chairing the "HDR Group" and "3DTV" activities. He is currently serving as associate editor for IEEE transactions on Circuit System and Video Technology, SPIE Journal of Electronic Imaging and SPRINGER EURASIP Journal on Image and Video Processing.